Stable Mechanical Design of Coherent X-ray Scattering Beamline at Taiwan Photon Source

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Abstract

The Coherent X-ray Scattering (CXS) Beamline is one of the phase-I beamlines at Taiwan Photon Source. This beamline is mainly designed for advanced experimental techniques of X-ray photon correlation spectroscopy, coherent diffraction imaging, and small-angle X-ray scattering with operating energy of 5 - 20 keV. To optimize the wide applications of the advanced CXS techniques, the beam sizes in horizontal and vertical directions at sample are adjustable within 1 - 10 μm by controlling focusing mirrors, secondary source slits, and other optics in the CXS beamline. Consequently, the optical components for defining beam sizes are very critical for beamline performance, and required to be precisely designed with high stability. The mechanical resolution and accuracy of the components should reach submicron level to sustain the advanced techniques at the CXS beamline. Moreover, ambient vibration and temperature fluctuation at the CXS beamline are also important issues for stability of components. To minimize the influence of environment uncertainties, a precise temperature controlling system is designed to be adopted on all critical components. Recently, the precise temperature controlling system and stable design of slits components have been accomplished and commissioning. The overall design concept and mechanical specification for slits components and precise temperature controlling system will be reported in this paper.

I. Mono beam slits system

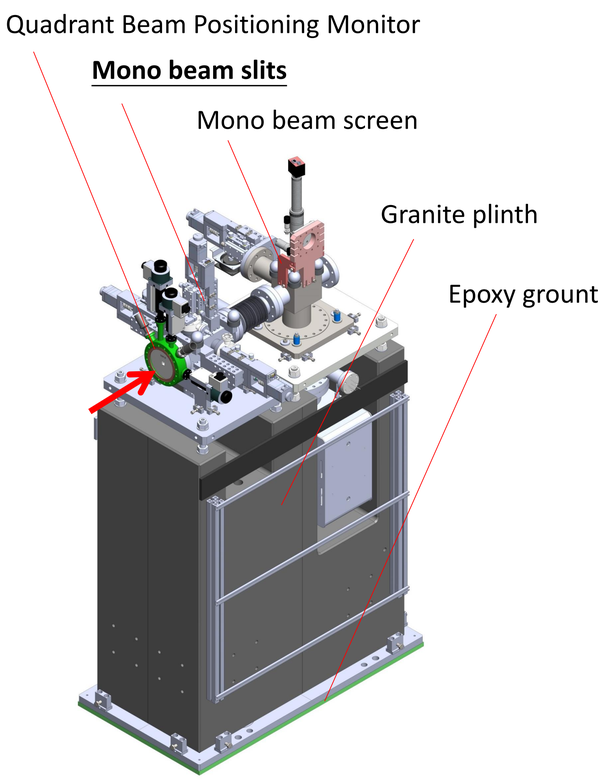

Figure 1. Integrated system for Slits and beam monitoring.

Table 1. Specification of mono beam slits

Maximum aperture	10 mm (H) × 10 mm (V)
Movement range (each blade)	± 5 mm
Position resolution	≤ 0.1 μm
Position repeatability (closed-loop)	≤ 0.5 μm
Position accuracy (closed-loop)	≤ 1 μm
Material	Tungsten alloy
Straightness	1 μm over 10 mm
Surface finish on beam intercepting face	≤ 0.1 μm Ra
Parallelism of slit blades	≤ 20 μm

Stand and base
- Granite plinth on epoxy grount base
- High thermal inertia
- High damping capacity

Thermal stability
- Precise temperature controlling system

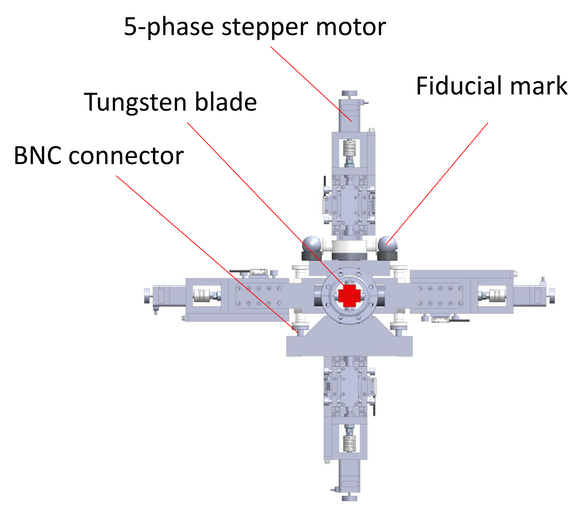

Figure 2. Mono beam slits.

Table 2. Specification of secondary source slits

Maximum aperture	13 mm (H) × 13 mm (V)
Movement range (each blade)	± 6.5 mm
Position resolution	≤ 0.006 μm
Position repeatability (closed-loop)	≤ 0.018 μm
Position accuracy (closed-loop)	≤ 0.2 μm
Material	Tungsten carbide GaAs single crystal
Surface finish on beam intercepting face	≤ 0.1 μm Ra
Parallelism of slit blades	≤ 10 μm

Stand and base
- Granite plinth on epoxy grount base
- High thermal inertia
- High damping capacity

Thermal stability
- Precise temperature controlling system

Material
- Low coefficient of thermal expansion, Invar

Vibration reducing for slits
- De-coupled from the chamber.

II. Secondary source slits system

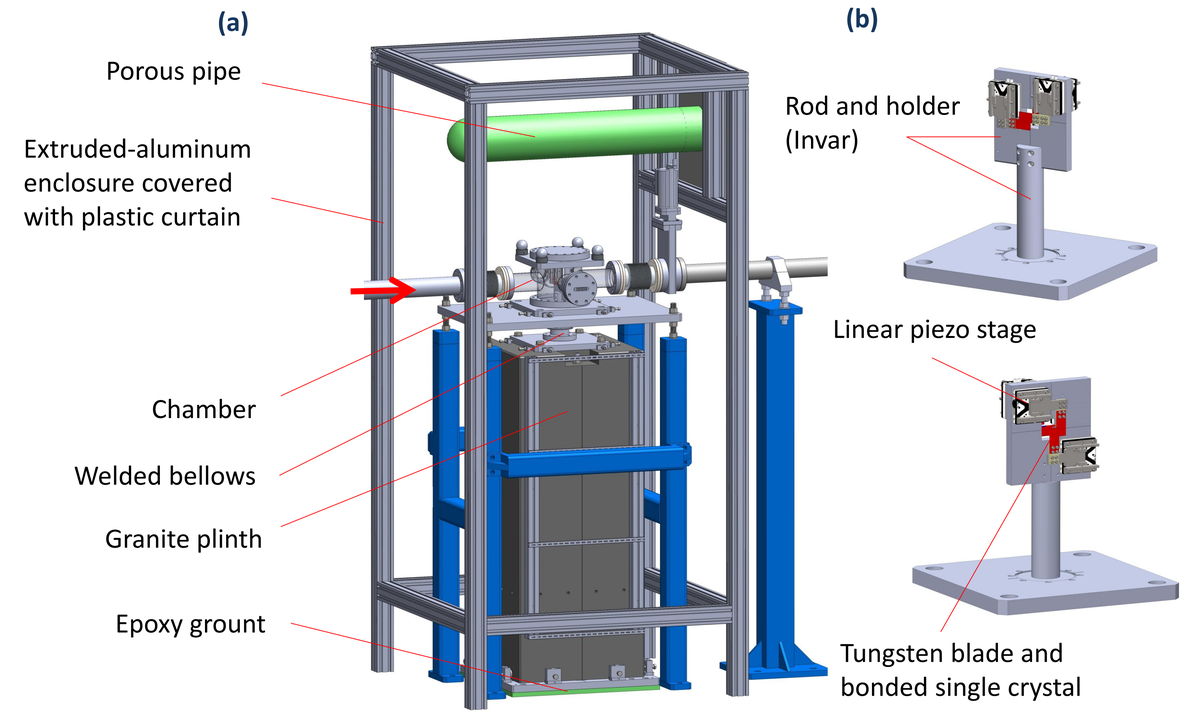

Figure 3. (a)Secondary source slits inside extruded aluminum enclosure. (b)Slits and holder

III. Precise temperature controlling system

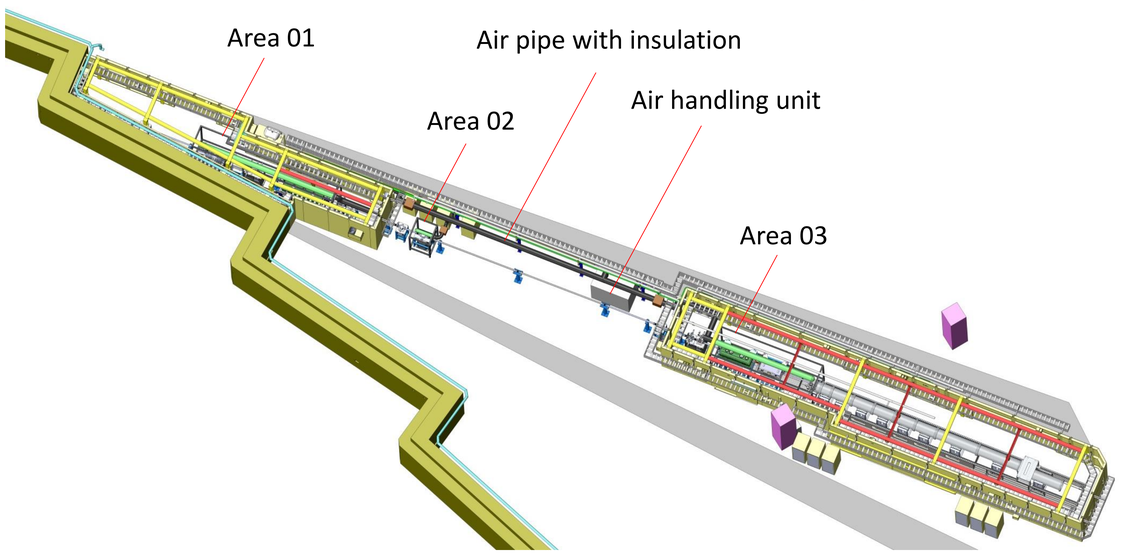

Figure 4. Schematic of precise temperature controlling areas

System type
- Heating, ventilation and air-conditioning (HVAC)

Real-time controlling method
- Coil-type heat exchanger
- Flow rate controlling for chilling and heating coils

Stability of temperature
- ±0.02 ℃

Conclusion

The slits components and precise temperature controlling system for CXS beamline have been designed, fabricated, and preliminary tested. Issues involving mechanical instability are considered, and preventive methods are adopted on every slits system for optimizing their performance. However, problem of heat sources from electronic components, such as ionization gauges and stepper motors, has not been confirmed. Estimation of heat sources using flow simulation and particular test needs to be on going to assure the set-up and parameters of precise temperature controlling system.